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KEY

TO

A CHART

OF THE SUCCESSIVE

GEOLOGICAL FORMATIONS,

WITH AN ACTUAL SECTION FROM

THE ATLANTIC TO THE PACIFIC OCEAN.

ILLUSTRATED BY THE

CHARACTERISTIC FOSSILS OF EACH FORMATION.

BY

JAMES HALL,

PALEONTOLOGIST TO THE GEOLOGICAL SURVEY OF THE
STATE OF NEW YORK.

BOSTON:
GOULD AND LINCOLN,
59 WASHINGTON STREET.
1852.

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State Normal School at Salem.

No. ~~3894~~

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PREFACE.

THE preparation of the Chart of the Geological Formations was undertaken at the request of S. S. Randall, deputy superintendent of the Common Schools of New York and editor of the Common School Journal, and of A. G. Johnson, deputy secretary of the State of New York.

The object had in view was the introduction of the study of Geology into the schools with better means of instruction and illustration than then existed within the reach of the pupils.

The work was commenced in September,

1849, and completed in December following. Circumstances, which it is not now necessary to enumerate, have delayed its appearance much longer than could have been desired.

It is now issued, with the following pages of explanatory matter, in the hope that it may render a study so delightful in itself and so practically useful, more extensively introduced and more easily understood.

ALBANY, N. Y., *December*, 1851.

INTRODUCTION.

THE crust of the earth is found to consist of materials which are either in a loose condition, as soil, clay, sand, gravel, etc.; or consolidated in the form of what are commonly called rocks, as limestone, slate, granite, etc. All these, however, are termed rocks by the geologist.

These rocks are arranged in successive beds or layers, one above another, and are more or less distinctly marked by their mineral character, or by the fossils they contain. Most of these layers or strata were originally formed in a horizontal position, but have been subsequently deranged and displaced, so as to be tilted up, and stand in more or less inclined positions, or even sometimes to be entirely overturned. It is owing to this circumstance, that we are able to explore the strata to a very great depth, and without the necessity of excavating;

since those beds which are really the lowest, are often broken up, and have their edges raised to the surface, or even to great heights beyond other layers which are above them in the geological succession.

It is within the province of geology to determine the true position of each layer, and its relations to those above and below it, however confused or obscured may be their present condition; and to present the evidence on which this determination is sustained.

The chart, to which this book is an accompaniment, is designed to exhibit to the eye the order in which the successive layers or strata of rocks are arranged, as it has thus far been determined by geologists; and, also, the characteristic fossils which have mainly afforded the key to this arrangement. It is intended to exhibit the appearance that would be presented if a section, or cut, were made from the surface towards the centre of the earth, thus exposing the different layers to view by their edges. It is, in fact, such a representation as may be seen in the banks of many rivers, as the Niagara, or in the high, rocky cliffs of the lake or ocean shores, only it is much more extended than any such natural exposures.

GENERAL DESCRIPTION OF THE CHART.

Towards the left hand side of the chart there is represented a large mass of rock colored red, which is regarded as the basis upon which, or against which, all the other rocks rest. To the right of this are represented the several successive strata or layers composing the entire series of stratified rocks. By observing the direction of the stripes which represent these strata, and which are in truth as we find them in nature, it will be seen, that by passing along the upper margin, from *right* to *left*, we pass over the strata in the same order as they occur in passing downwards along the right hand margin of the section. In other words, we may obtain the same information by travelling along the surface of the earth as we should do by penetrating downwards towards the centre.

In no limited region of country will all the strata here represented be seen; nevertheless, all these strata, and all the phenomena exhibited, from the granite peak on the left, as far to the right as the limits of the Carboniferous formation, may be seen in travelling over the country from the northern part of New York to the centre of Pennsylvania. In this way, we pass in succession over the outcropping edges of the different layers which lie one above another, in the same order and with the same regularity as are there represented. Many other portions of country would furnish similar examples of this order of succession, more or less complete.

Since the higher strata are mainly formed out of the ruins of those below them, it is more satisfactory to begin our investigations with the lowest beds.

Let us begin, therefore, on the left of this series, next to the granite, and proceed along the surface (or upper margin of the section) to the right.

Lying next to the mass marked granite, is a broad purple or grayish colored stripe marked *Gneiss* and *Mica Slate, with beds of crystalline limestone;* and, in another part of the same, *Quartz rocks*, *Sandstones*, *Conglomerates*, etc.; which names are sufficiently indicative of the character of the rocks occupying this place in the series.

Above this, the entire series of rocks is arranged under three grand divisions.

I. PALÆOZOIC ROCKS. II. SECONDARY ROCKS. III. TERTIARY and MODERN ROCKS.

I. THE PALÆOZOIC ROCKS (from παλαιὸς, *ancient*, and ζωὴ, *life*) are so called from containing the oldest or most ancient forms of plants and animals in a fossil state. These are subdivided into, 1. SILURIAN SYSTEM, 2. DEVONIAN SYSTEM, 3. CARBONIFEROUS SYSTEM.

The Silurian System is again divided into upper and lower, by a well-marked line of separation.

Adjacent to the granite, we have represented a portion of this system, in which the strata have undergone certain changes, and have assumed a peculiar condition, termed METAMORPHIC. Rocks of this character are not peculiar to the Silurian period; but rocks of any age or of any system may undergo similar changes, by the agency of intense heat; as the contact or proximity of highly heated vapors, or melted masses of rock.

II. THE SECONDARY ROCKS are so called from being in a somewhat different condition from those below them, but mainly from containing an assemblage of fossils of different types from those of the preceding formations, indicating a second period in the age of the rocks. This division comprises, 1, the NEW RED SANDSTONE SYSTEM, which is again subdivided into the PERMIAN SYSTEM and the TRIASSIC SYSTEM; above which are, 2, the OÖLITIC SYSTEM, and 3, the CRETACEOUS SYSTEM.

III. THE TERTIARY and MODERN ROCKS comprise the third great division of rocky strata, marked by fossils which differ essentially from those of the preceding formations, approaching more nearly to existing forms. In this division are included, 1, the TERTIARY SYSTEM proper, and, 2, the QUATERNARY, or deposits of recent production.

On the upper part of the map are arranged a series of figures of fossils from the systems of rocks just enumerated. These fossils are enclosed in compartments, separated by vertical lines, and within each one of these are represented those fossils which are most important, and characteristic of the system to which they belong. They are, moreover, so arranged, as to be nearly over the upper or outcropping edges of the different systems which they represent.

In order fully to comprehend the subject illustrated upon this chart, it will be necessary to return to the starting-point, viz., the granite nucleus, and to pass again from left to right, noticing more particularly the several subordinate formations of which the systems are composed.

The *gneiss*, *mica slate*, *crystalline limestone*, and other rocks included in the first division, above the granite proper, are not to be regarded as belonging to the Silurian System. They constitute a series of more or less crystalline rocks, in which, thus far, no fossils have been discovered; and they are more intimately related to the granitic rocks below, than to the formations above them. From their stratified condition, they are regarded as having been originally deposited in water, and subsequently, by the action of heat, to have become remarkably altered, and crystalline in structure.*

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* This assemblage of strata is known as the AZOIC SYSTEM.

The rocks of this period are interesting and important from containing the extensive beds of specular and magnetic oxide of iron, in different parts of the United States.

The series of quartz rocks, sandstones, conglomerates, and other rocks overlying these, and represented in the upper part of the same division, are also highly metamorphic, and contain, in some places, veins of copper ore, as indicated upon the chart.

With the blue stripe above the rocks just noticed, commences the SILURIAN SYSTEM, the lowest rock of which, yet known, is the Potsdam sandstone and its associated conglomerate. It is in this rock, also, that we find the first organic remains.

It will be observed, that at the extreme left hand, several of the lower divisions of this blue stripe are represented in a folded and contorted condition, unlike the same formations farther to the right, which are but slightly undulating. These are termed "METAMORPHIC ROCKS" of "*Silurian age.*" They are more or less crystalline, and their general features are quite unlike the same rocks where they are unchanged. In tracing them to the right, they gradually lose this character, and assume that of unaltered, stratified rocks, such as sandstone, limestone, shale, etc.

Since such examples are of frequent occurrence in nature, and in rocks of various systems, the connection of the two has been shown; and we have, for example, at the beginning of this formation, colored blue, the terms "*Gneissoid and Granular Quartz rocks*, which are metamorphic states of the Potsdam sandstone." In other words, the Potsdam sandstone, when altered by igneous action, becomes first a granular, more or less crystalline quartz rock, and finally passes into gneiss.

Next above this we find "*Crystalline Limestone;*" and again, in a continuation of the same beds, "*Crystalline limestone, Variegated and White Marble*," which are metamorphic conditions of the following limestones, viz., *Trenton*, *Black River*, *Birdseye*, and *Chazy limestones*, and *Calciferous sandstone*. The *various limestones* named, become crystalline, from the action of the igneous rocks on the left and below them, and furnish the white and variegated marbles.

In the same manner, the succeeding Chloritic, Talcose, and Mica Slates are metamorphic conditions of the Hudson-river group; which is itself susceptible of separation into several subordinate groups of shales, shaly sandstones, etc., as indicated in another part of the division.

From this point, or from the commencement of the Oneida conglomerate, the names first written in the subdivisions of the formations, and enclosed between parallel lines, are those by which the rocks are known in their unaltered condition. Returning to the upper margin of the section, and reading downwards, the names following those of the rocks are the names of localities or places where the same rock may be examined to advantage, either in ravines, cliffs, or river banks. A few only of the more important localities are indicated, beginning with those in America, and followed by those of foreign countries, where the same rock is known to have been discovered.

It will be seen, that in some instances, the names of two or more rocks are included in the same subdivision, or between the same parallel lines. In these instances, the rocks are closely allied to each other in character, and are not sufficiently distinct to require subdivision by lines. The names are arranged in the order in which the rocks occur in nature. As an example, we have the Calciferous Sandstone, the Chazy, Birds-eye, Black River, and Trenton Limestones, in one subdivision. In these groupings, the name of the locality is placed as nearly as possible to succeed the name of the rock.

The names of these rocks will also be found repeated near the right hand margin of the chart, and, in the same order, from below upward, as they occur from left to right on the upper margin of the section. In this column will also be found the names of still more minute subdivisions, into which some of the rocks or groups have been separated in the geological surveys of New York.

For example, the Hudson-river group consists of three distinct members: the *Utica Slate*, the *Frankfort Slate*, and the *Pulaski shales* and *Sandstones*. The division marked on the upper margin of the chart as Lower Helderberg limestones is shown, on the right hand margin, to be composed of the *Tentaculite* or *Water limestone*, the *Pentamerus limestone*, *Delthyris shaly limestone*, and *Upper Pentamerus limestone*, divisions which are easily recognized in some places, but are very obscure in others.

The same may be said of the Upper Helderberg limestones, which are capable of subdivision into three distinct masses. The subdivisions into which the Hamilton group can be readily divided, are shown a little within the right hand margin, and to the left of the name of the group itself.

In several instances, the names by which groups, or rocks of the same age, are known in England are given in parentheses, at the lower end of the stripe, as the *Wenlock Formation*, corresponding in part with the Niagara group; *Caradoc sandstone*, with the Hudson-river group.

In this manner, the strata are all marked as far as, and including, the Coal formation. Above and beyond this, it will be found that the names of localities do not, in every instance, immediately follow the name of the rock. This difference indicates that the rocks have not as yet been distinctly recognized in this country, and, therefore, no American locality is inserted.

From the Coal period upward to the Tertiary, the formations are preëminently European; they are extensively and very perfectly developed in England and upon the continent, and form a great and prominent geological feature.

Of the Tertiary System, the two lower members, Eocene and Miocene, are fully recognized in many localities; while those strata usually denominated Pliocene have not yet been so distinctly recognized, and therefore no American localities are given.

In the Modern or Quaternary system of deposits, no localities have been given, for want of space.

From the commencement of the Secondary Rocks, therefore, the English names of the rocks are first introduced, and next to them those of Continental Europe: first, the German name, in German letters; and next the French name, in scrip type; and beyond these are given, in Italic capitals, first the names of the continental localities, and finally the English ones, the English name of the rock being again repeated at the right hand margin of the section. As an example, under the NEW RED SANDSTONE SYSTEM, take the *Magnesian limestone*, the second rock above the Coal measures. This rock has no positive representative in America. Its German name is *Zechstein* and *Kupfer Schiefer*, (the latter a layer of copper-bearing slate;) and the French name following it, *Calcaire magnesien*, is simply a translation of the English. Among the prominent localities are Mansfeld, in Germany, and East Thickley, in England, as given on the chart.

In the OÖLITIC SYSTEM, the Lias has been recognized in this country, from certain fossils found in the coal beds of Richmond, Virginia; and above this, none of the members of this system have been recognized in the United States, and consequently no names of American localities are found after the names of the rocks.

It will be seen that each of these systems is made up of several subordinate groups of individual rocks. It will be observed, moreover, that rocks of the same denomination are repeated in almost every one of them. Thus *shale*, *sandstone*, and *limestone* occur in all the systems of the Palæozoic Rocks. In their general aspect and character, these rocks, in the different systems, are much alike; and it is often only by their contained fossils that we are able to distinguish them. This repetition of deposits of similar character arises from a continuation or a repetition, at different and successive periods, of causes similar to those giving rise to the first deposits.

Since all these strata, with the exception of the limestones, were deposited from the mud, sand, and silt carried into an ancient ocean, there must be an entire absence of a formation where dry land existed at the time; and it will very naturally be presumed that it cannot have the same thickness in all parts of its extent. This is not only true, but many of the formations thin out entirely, leaving the one above and the next below to come in contact. As examples of this, which are represented on the chart, we have the *Oneida conglomerate*, a rock made up of sand and pebbles, which, in its greatest development, has a thickness of several hundred feet. In the same manner, the lower *Helderberg limestones* are represented as thinning out entirely, a feature which is remarkable in those rocks. The *Oriskany sandstone* and *Cauda-galli grit* also thin out entirely. The same feature is represented in some of the rocks of the secondary period, and, as before said, it may occur in any of them.

This thinning out may arise from the fact that in the wide and deep ocean certain deposits never reached the deeper portions, but subsided along its shores. Or it may have been caused by certain portions being too shallow, or even upraised above the level of the water. It may also have occurred in another way. After the deposition of the stratum, it may have been uplifted so near to the surface of the sea as to have been worn away by the waves, and thus have allowed a succeeding deposit to come directly upon one of preceding date. Such operations have sometimes taken place to a considerable extent. We have an example of this erosive action at the termination of the Carboniferous formation, where the upper undulating surfaces of the strata of the Coal period have been worn down, and in some places present considerable depressions, from which the strata have been removed. The evidence of similar erosive action is visible at the termination of the Cretaceous system, and before the Tertiary strata were deposited. The same causes have doubtless operated, in many instances, where no evidence is now preserved in the remaining portions of the formation.

The QUATERNARY or MODERN SYSTEM of deposits is represented on the section as covering only a small portion of the surface. This has been done to avoid confusion; though we know that, in nature, the materials of this age cover almost the entire surface. They have been deposited after the older formations, and since the uplifting and breaking up of the lower rocks, and consequently lie in a horizontal, or nearly horizontal, position upon the edges of these rocks, when upturned, or upon their plane surfaces when they have not been thus uplifted.

The same is also true of the Tertiary deposits which have often been made upon the upturned edges of the Palæozoic rocks, and are thus shown, in a single example, lying upon the edges of the Carboniferous strata.

We will now direct our attention to the stratified deposits on the left of the granite peak.

The rocks of *Secondary age*, the New Red sandstone, Oölitic and Cretaceous formations, are there represented as resting on gneissoid or granitic rocks. The strata are shown as more or less undulating, and becoming contorted in their proximity to the igneous rocks below, and even entirely metamorphic in their character.

Strata of this age, both in their normal condition and in various stages of metamorphism, are the prevailing rocks of the Alps, the Jura, and the Apennines; and towards the south they are overlaid by Tertiary strata, through which rise the ancient volcanic vents and active volcanoes of Southern Europe, while the lavas have flowed over the surface. It is intended, in this sketch, to combine the exhibition of phenomena which are in reality connected in nature, though spread over a wide surface.

Besides the formations we have been considering, another series of bands may be seen rising in nearly a vertical direction, traversing or cutting through the strata previously described. These rocks penetrate from below upward, sometimes reaching to the surface, and in other cases terminating in the older formations.

The two on the extreme left are intended to represent volcanic chimneys passing from the sources of volcanic fires to the surface.

A column of lava is represented as rising through a fissure in the granitic and secondary rocks, dividing above, and extending to two distinct cones, where the volcanic fires have ceased to be active.

To the right of this column is represented another, originating from a vast reservoir below, and which rises to the surface through two distinct cones, exhibiting the character and phenomena of active volcanoes.

The others represent Trap dikes, Greenstone dikes, Porphyry dikes, Granite veins, &c.

From their character and condition, they have evidently been forced up from beneath, in a state of fluidity, penetrating the superincumbent rocks through fissures and between strata. Among the attendant phenomena of the intrusion of these dikes and Granite veins is the production of *faults;* that is to say, fractures and dislocations of the strata, which often extend through a very great thickness, or even for an entire system of strata. The illustration of these phenomena is made by a black line following the dislocation of the beds, on each side of which the strata are displaced, so as no longer to be continuous.

The occurrence of metallic veins in various rocks is represented by lines of color, as well as by name. The production of these rocks is regarded as due to the same causes which produce and sustain volcanic action at the present time. The fluid lava penetrates the adjoining rocky beds through fissures, and, on cooling, becomes dikes, analogous to those penetrating the more ancient rocks. Portions of the fluid matter also flow over the surface, and accumulate in immense masses, even covering large tracts of country. The same feature is attendant on the Trap dikes, and, in many instances, extensive areas are covered by rock precisely similar in character to that forming the dikes, but assuming a columnar form, as represented on the upper margin of the large section, above the New Red sandstone system, and the other above the Cretaceous system. Rocks of this kind, and having this position, are termed basalt, or basaltic rocks.

Although there is a variety of character and composition in the nature of these ancient dikes, it is not so great as the variety among the products of modern volcanoes.

In the section which has just been described, all the important geological formations known to exist are brought together and presented in their true order of succession. It is true, that no single locality or moderate extent of country will furnish all the rocks here exhibited.

The low section at the base of the chart is one exhibiting the successive rocks and formations which appear along a line, from the Atlantic to the Pacific Ocean, and will afford a good idea of the condition in which rocks are found, with all their disturbances and deficiencies, when examined over a large extent of country.

Beginning at the eastern extremity, in Nova Scotia, we have a well-defined Coal Formation of the age of that represented upon the larger section above. As we go westward, we find rocks of the Devonian and Silurian periods coming out from beneath those of the Carboniferous period, precisely as is represented in the larger section. In pursuing this direction, however, we soon find the rocks folded and contorted, and becoming crystalline in their character, like the metamorphic rocks represented to the right of the granite, in the section above. In travelling entirely across the White Mountains and the Green Mountains, we find no rocks older than those of Silurian and Devonian age, with occasional intrusions of granite veins and Trap and Greenstone dikes. The section is upon too small a scale to allow of the minute representation of all these phenomena. In the valley of Lake Champlain, between the Green Mountains of Vermont and the Adirondack Mountains of New York, the Silurian rocks are less folded, and gradually lose their metamorphic character, revealing again their fossils in great numbers.*

Between the Champlain valley and the central portion of the Adirondack Mountains, the Gneiss, Mica Slate, and Crystalline limestones (of the age of those next the Granite in the large section) come in, in great force, containing extensive beds of iron ore. In the centre of this chain are immense masses of peculiar granitic rocks, forming high mountain peaks. Again, to the west and south-west are the Gneiss rocks, and, above them, the Silurian strata, in a disturbed and partially metamorphic condition. From this point, the Silurian strata dip regularly to the south-west, and we pass over their outcropping edges, and those of Devonian and Carboniferous systems. In this direction, however, we find no higher formations succeeding the coal field of Pennsylvania, and, after passing for a long distance over its various members, as exposed in the valleys and watercourses, we descend again to the westward, passing over the outcropping edges of the various members of the Carboniferous, Devonian, and Silurian systems, as far as the rocks of the Hudson-river group. On the west side of the coal field, therefore, the successive formations are precisely in the same order, from left to right, as upon the section above. The student will understand, that the rocks represented as coming out from beneath the coal formation, on either side, are also continuous beneath that formation, and constitute a part of the great system which so largely pervades the country.

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* It may be remarked here, that even as far east as the Connecticut River some of the strata still preserve their fossils.

From this section, it can be readily understood how the coal field of Pennsylvania has once been continuous with that of Illinois, farther to the west; and that they have been separated by that agency which has upheaved the lower rocks between, and caused them to dip in opposite directions. When these rocks were uplifted, their edges became broken, and, in this condition, were exposed to the action of water, which has covered the surface; and by this and other agencies, these projecting rocks have been worn down, and the two coal fields so widely separated. On the western side of this elevation, marked by Cincinnati, we find a repetition of similar rocks, dipping again beneath the Illinois coal field, and, in part, reappearing on the western side, along the Mississippi River.

Beyond this point are again carboniferous rocks and coal fields, the character and extent of which are not fully known.

In this western direction, we find rocks of the Cretaceous system resting directly upon the Carboniferous rocks. By a reference to the large section above, it will be seen that this implies the absence of the New Red Sandstone and Oölitic systems, which, as before remarked, are usually absent in American localities. Between the mouth of the Kansas River and the summit of the Rocky Mountains, there is a wide extent of rocks belonging to the Cretaceous system, and from beneath which appear metamorphic and highly crystalline strata. To the westward, upon these metamorphic rocks, at intervals, rest formations of Tertiary, and even, perhaps, of Cretaceous age. The fossil plants and shells, however, that have been collected, are all of the Tertiary period.

At all points along this line of section, west of the Cretaceous formation, where the names of rocks are given, it is from specimens that have been collected by Captain Fremont and others. At intervals, Basalt and Trap, with more recent volcanic rocks, are known to occur, and active volcanoes exist on the western slope. The metamorphic rocks underlying all this region are probably all of Palæozoic age; and those towards the western margin belong to the Silurian system.

One of the most striking features presented in this section across the country, is, the great difference in elevation between the eastern and western portions of the continent. This difference would be the more striking, were the line carried west, over the higher mountains, as it is at the east; but it follows a line of travel much below the mountain peaks, which are sometimes represented in the background. This is a very interesting and very important feature in our continent.

CLASSIFICATION AND ORIGIN OF ROCK FORMATIONS.

Rocks are classified and arranged in systems and groups, according to their mineral characters and their fossil remains; and these are intimately associated with considerations regarding their origin and deposition.

One of the most obvious distinctions which first occur is the subdivision of rocks into *stratified* and *unstratified*. These terms, moreover, indicate the origin or mode of production of these different formations; for the unstratified rocks are those which have originated from igneous action, or whose earliest condition has been that of fluidity from heat. These rocks, moreover, are always crystalline in structure; though this character alone is not sufficient to distinguish them from each other, or from stratified rocks which have been subjected to heat.

The *stratified* rocks, on the other hand, have had their origin from water, and are called sedimentary rocks. Their earliest condition has been that of sand, clay, or carbonate of lime deposited from water.

The unstratified and crystalline rocks are variously associated with the stratified rocks, and not always below them. They are often seen breaking up through the stratified masses, and penetrating them in various ways.

Rocks are represented on the chart in five different types.

(1.) The **Granitic** proper, including the great central mass, and the granitic veins which penetrate to the Silurian rocks.

(2.) The **Trappean**, including the porphyry dikes, which, having their origin below, penetrate the Gneissoid rocks, the Silurian, the Carboniferous, and even the newer secondary strata; and may be found associated with the Tertiary rocks. These have not only penetrated the strata from below, but have sometimes flowed over the surface.

(3.) The **Volcanic**, which may penetrate any of the strata, and, in a melted state, flow out over the surface of the superficial beds.

(4.) The **Metamorphic**, which are shown next above the Granite, as gneiss, mica slate, quartz rocks, sandstones, crystalline limestones, &c. These rocks, though evidently stratified, as if originally deposited from water, have become so altered by igneous action, that their normal character is lost. No fossil remains have ever been found in the rocks of this period.

Beyond these, we find in the rocks of Silurian age, gneiss, mica, and talcose slates, and crystalline limestones, which are distinctly traceable to their original conditions in the strata further to the right.

We have also on the left of the granite, strata of the New Red Sandstone, Oölitic, and Cretaceous formations, becoming metamorphic.

We thus perceive that though these rocks belong to different parts of the stratified series, they are nevertheless similarly changed by the same agencies, the slates of any period becoming talcose and mica slates, the sandstones becoming gneiss, the gray, yellow, or blue limestones crystalline marble of various colors.

(5.) The STRATIFIED or SEDIMENTARY rocks, which, in their unaltered condition, occupy the larger portion of the chart to the right hand, and above those previously noticed. These rocks have generally undergone no change from their original condition of beds of mud, sand, and carbonate of lime, except that in most cases they have become indurated or stony in their character.*

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* The student will understand the necessity of including all deposits whatever as rocks, without regard to their condition of

These formations being altogether the most important and extensive, have been examined with great care; and from all the facts obtained, both of their mineral character and contained fossils, they have been arranged in subdivisions, as shown on the chart.

This succession, as here given, represents the order in which each one has been deposited above the other; and since each formation in turn has been the uppermost, or the surface on which the plants and animals have lived which are now found imbedded in the rocks, they represent so many epochs in the earth's history. Each one, even of the minor subdivisions, represents what is equivalent to a condition of the earth covered by its plants and animals, as in its present actual condition. In other words, were the entire present creation to be destroyed and covered up by various sedimentary deposits, the whole would represent, in the continuation of the geological succession, only one of the lesser subdivisions of any of the systems.

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cohesion or induration, when he is told that the Potsdam Sandstone is, in many places, no more coherent or indurated than are beds of sand or gravel of the latest periods; and its condition, as a stony or indurated rock, is by no means indicative of its age.

I. SILURIAN SYSTEM.

Above the system of Rocks designated as Metamorphic, commences a succession of stratified deposits, marked every where by the presence of fossils. The first subdivision of this great series is known as the SILURIAN SYSTEM.

From the great thickness of this system of rocks, it has been found necessary to divide it into *upper* and *lower*. The line of separation is marked, to a great extent, in the United States, by a rock made up of coarse sand and pebbles, or becoming in some places a coarse sandstone. This subdivision is given on the chart at the *Oneida conglomerate.*

In the United States, we recognize all the divisions of the Silurian system given on the chart.

*Characteristic Features of the Successive Beds.**

Potsdam Sandstone. This is the lowest member of the Silurian system. It consists of an aggregation of water-worn sand, sometimes with pebbles forming a conglomerate. The rock is usually compact and fine grained.

In its metamorphic condition, it becomes a compact, crystalline quartz rock, or, in some situations, assumes the character of gneiss.

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* The teacher should point out to the pupil these successive rocks on the chart, as he reads these descriptions. He will also find indicated some of the principal localities.

The principal fossils of this rock are two or more species of Lingula. Some remains of trilobites and other fossils have been found.

When compact, it is an excellent building stone.

Calciferous Sandstone. This rock usually consists of a mixture of calcareous and siliceous particles, whence it derives its name. It contains cavities lined with quartz crystals, and has also layers or nodules of chert, showing that the siliceous matter has been in solution. At the west it is known as a magnesian limestone, and is not very siliceous. Some portions afford a hydraulic cement.

It breaks in rough, irregular blocks, and, except in some of its localities, is fit only for a rough building stone.

This rock contains quartz crystals, calcareous spar, lead ore, and copper ore, and often small nodules of anthracite coal.

The Chazy, Birds-eye, Black River, and Trenton Limestones, form a group not always distinguished from each other. They are, however, distinct, and easily recognized by their fossils in the eastern part of the United States.

Chazy Limestone, from the town of Chazy, on Lake Champlain, where it is very well developed, consists mainly of two members; — the lower is a light gray, and, for the most part, encrinal limestone; and the upper, a dark blue or nearly black limestone. It occurs on both sides of Lake Champlain, and upon the Isle la Motte, where it is extensively quarried.

This rock contains no valuable minerals or metals.

When metamorphosed, it forms, with the succeeding limestones, a crystalline marble.

Its fossils are numerous and characteristic.

The *Maclurea*, and other characteristic fossils, being cut in various directions in the slabs of marble sawed from this rock, appear in great beauty. It is largely used for flagging stones for the floors of public buildings.

Birds-eye Limestone. This rock is of extremely fine texture, of a light bluish color, weathering to a drab or whitish ash color. It is even-bedded, readily breaking into slabs, and very durable as a building material; — it is extensively quarried along the Mohawk valley and other places.

This name is derived from the appearance given by numerous stems of a plant-like fossil, which penetrate the layers vertically, as if the calcareous mud had been deposited around them while growing; and when the surface is polished, the ends of these stems present circular spots.

The principal fossils of this rock are the one just mentioned, with a few corals and some chambered shells.

This rock can be traced westward for many hundred miles, still retaining the same characters as in New York. It is quarried at Frankfort, Kentucky, where it is of a light ashen color.

Black River Limestone. This limestone is grayish or bluish gray, coarser and less regularly bedded than the Birds-eye.

Although a thin mass, it can be traced over a wide extent of country, and is recognized by its fossils as far west as the Mississippi River.

Its characteristic fossils are a coral and an Ormoceras, (No. 63 on the chart.)

Trenton Limestone. This is a more important rock than the three others preceding. It covers an extensive surface in the State of New York, particularly along the valley of the Mohawk and its tributaries, and in the valley of the Black River. It forms the Trenton Falls, on West Canada Creek. The rock is for the most part black or very dark, thin-bedded or shaly, or with shale alternating with thin bands of limestone. Many of the layers are concretionary, or nodular, in structure. Some portions are regularly bedded, and afford good building stone; the upper portion is often thick-bedded, of a gray color, and crystalline in texture; and this portion especially furnishes an excellent building material.

West of New York this rock becomes gradually thinner and lighter colored, and on the Mississippi River consists of thin shaly layers, which weather to a drab or ashen color. This limestone, with those below it, are known to be continuous, from the western part of New England, in the direction of the great lakes west and north-west, to beyond the Mississippi River, and south-west as far as Alabama.

The great valley of Virginia occurs in the limestones of this period.

Fossils are extremely numerous in this rock, and some of them extensively distributed and characteristic, being found over many hundreds of miles in extent.

The Trenton and other limestones of the Mohawk valley are metamorphic east of the Hudson River, becoming partially or entirely crystalline. These are the white and variegated limestones of the western part of New England.

In an economical point of view, therefore, these limestones are very important, furnishing excellent building stones in their normal condition; and again in their metamorphism affording beautiful materials for building, statuary, and ornament.

Hudson River Group. This group of strata consists of shales, shaly sandstones, and sandstones, with bands of impure limestone, and sometimes thicker beds of limestone alternating with shale. West of New York the calcareous matter increases in proportion, and the whole group becomes one of shale and limestone, with no sandstone, and scarcely any arenaceous shale. It thus becomes very different at widely separated localities, and it is only by studying intermediate points that we arrive at a knowledge of the changes which gradually produce these great differences.*

This group of rocks can be traced from the valley of the Hudson River westwardly and north-westwardly, through the valley of the Mohawk to the shores of Lake Ontario, and thence west through Canada to the shores of Lake Huron, and even to the northern shores of Lake Michigan. It also covers a large area in Ohio, Indiana, Kentucky, and Tennessee.

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* The pupil should always recollect that a sedimentary deposit will change in its character when extending over a wide area. When we consider the conditions under which such deposits are made, it is easy to understand how this change is produced. Streams bring down mixed sediment of sand and mud, and flow into an ocean where the current is less; consequently the heavier particles, no longer suspended by the force of the stream, fall down. The finer mud particles flow on, in very quiet water remaining some time suspended, and, with a moderate current, will be carried to a great distance. From this cause, shaly deposits will always be more extensive than arenaceous deposits of the same period. This is readily illustrated by the smallest stream flowing into a pond; or it may be illustrated by an artificial stream into which the pupil may throw sand and mud, which, transported to a reservoir where the current is checked, will be thrown down at different distances from the inlet.

In many parts of this extent it is highly fossiliferous, and the seas of tropical climates of the present day scarcely any where furnish a more numerous and varied fauna than these very ancient strata.

The rocks of this group, when metamorphic, produce chloritic, talcose, and mica slates, as shown in the chart, towards the granitic peak.

Oneida Conglomerate, or Shawangunk Grit. This rock is a coarse sandstone or conglomerate, resting upon the Hudson River group, and from which there is sometimes a gradual passage. It forms the line of division between the Lower and Upper Silurian. In many places this rock does not exist, having thinned out; and the Medina sandstone rests upon the sandstones or the terminating calcareous beds of the Hudson River group.

This rock is used for millstones, and the Esopus millstones are made from it. It forms the Shawangunk Mountain, in New York, and the continuation of the same range in New Jersey. It received the name of Oneida conglomerate from its occurrence in Oneida county, being the only conglomerate rock in that part of the State of New York. It there rests conspicuously on the rocks of the Hudson River; and the Medina sandstone being absent, it is succeeded by the Clinton group.

Medina Sandstone. This is a red or brownish, argillaceous sandstone, usually soft and readily disintegrating on exposure. Some portions are more siliceous, and furnish good building stone. It is a conspicuous rock at Medina, Orleans county, New York, the canal being cut through it for some distance. It forms the lower fall on the Genesee River, and the banks of the river to its mouth. It also forms the banks of the Niagara River at Lewiston, and a part of the cliff on either side for several miles above. In the eastern part of New York, it thins out, and is hardly recognizable.

It contains few organic remains; the most important are a species of Lingula and a marine plant.

Clinton Group. This consists of shales, sandstones, conglomerates, limestones, and beds of iron ore. Although of moderate thickness, it extends throughout the State of New York, occurs in Canada, and again upon the shores of Lake Huron and Lake Michigan.

The most important feature of this group, in an economical point of view, are the beds of iron ore, which are coëxtensive with the strata, and uniform for a hundred miles.

Niagara Group. This consists mainly of a mass of shale, and another of limestone above. The limestone forms the table-rock over which the Niagara River falls, and the shale below is the rock which is worn away by the action of the water and air.

The shale is soft and argillaceous, consisting mostly of clay, with a small proportion of lime. It contains iron pyrites, which decomposes on exposure, causing the rock to crumble rapidly. The limestone, on the contrary, is extremely durable, withstanding the effects of weather. It forms one of the best building stones in New York. The lower part, which is filled with the stems of encrinites, has been used for the beautiful series of locks at Lockport. The fragments of crinoids are often brown or reddish.

West of New York, the shale of this group becomes more calcareous, and finally the whole mass is a limestone. It extends from Niagara westward through Canada, along Lake Huron and Lake Michigan, and thence to the Mississippi River.

It has many beautiful and characteristic fossils; and by the presence of a certain coral, (fig. 10,) it can be traced over hundreds of miles across the western mounds and prairies.

Onondaga Salt Group. This group consists of shaly and marly deposits, composed of clay, and carbonate and magnesian carbonate of lime. The lower part is a red shale; the middle and upper parts are gray, greenish gray, and ashen colored.

In the State of New York it is chiefly important from its brine springs. These are principally confined to the valley of the Onondaga Lake, whence the name of the group. All the gypsum of New York, of any importance, is derived from these rocks.

Tracing the group eastward from Onondaga Lake, it thins out on the Hudson River, and westwardly becomes more calcareous, and finally it is not distinctly recognizable beyond the shore of Lake Michigan.

The soils formed from the decomposition of the rocks of this group, and of those of the Niagara group, are among the most fertile in the United States.

Lower Helderberg Limestones. These limestones have been described as the water lime or Tentaculite limestone, the *Pentamerus galeatus* limestone, the Delthyris shaly limestone, the Encrinal limestone, and the Upper Pentamerus limestone. Although each of these rocks is distinct and well marked in New York, they are not so easily distinguished individually elsewhere. The lower, first named, are dark colored and thin-bedded limestones; the next are thick-bedded, gray or bluish; the third a shaly limestone, and the two upper gray and crystalline.

In a westerly direction, these limestones thin out entirely; and, from the thinning of the Oriskany sandstone above them, the Upper Helderberg limestones rest upon the Onondaga Salt group, as shown on the chart at the right of the Trap dike. Southward they extend through Pennsylvania, Virginia, and Tennessee, where, from the absence of the Onondaga Salt group, they rest directly upon the Niagara group, and the fossils of the two are often mingled together.

II. DEVONIAN SYSTEM. *Oriskany Sandstone.* This rock succeeds the Lower Helderberg limestones. It is a friable, or sometimes calcareous sandstone, from which much calcareous matter has been removed by water. In other places, the rock appears to be a compound of lime and silex deposited from solution. In some parts it abounds in fossil shells, but in most localities the shell has been removed, and casts only remain. When the sedimentary deposit is coarser, and more readily penetrated by water, the forms of the shells have entirely disappeared, and cavities or shapeless casts alone remain. This rock forms the separation between the Silurian and Devonian systems, as now recognized in this country.

Cauda-galli Grit. This deposit succeeds the Oriskany sandstone. It is composed of a mixture of shaly or clayey matter and sand, crumbling down into angular fragments on exposure to the air. It is a dark-colored rock, weathering to a rusty brown, and contains no fossils, unless, perhaps, a marine plant, which produces very curious markings upon its surface, from which this name has been given.

Upper Helderberg Limestones. Included under this head are the *Schoharie grit*, and the *Onondaga* and *Corniferous limestones*. The whole together form a group, coëxtensive with the Palæozoic deposits in the United States. They can be traced from the Helderberg Mountains, and their continuation on the Hudson River, westwardly to the Niagara River at Black Rock; and thence through Canada, and across the Detroit River into Michigan: and also on the south side of Lake Erie, through Ohio, Indiana, Illinois, and Kentucky.

The limestones are gray, bluish, and black, the higher one containing much chert or hornstone. They every where are filled with great numbers of fossils, among which have been found remains of large fishes.

Hamilton Group. This consists of a series of shales. These have been distinguished as the *Marcellus slate*, which is black and slaty; the *Ludlowville shales*, more fissile, and of an olive color; the *Moscow shale*, which is bluish or grayish blue, and very fissile.

In the central and eastern parts of New York, this group contains large proportions of arenaceous shales and shaly sandstones. The subdivisions are not in all places conspicuous, and where the arenaceous deposits prevail, none can be distinguished except the lower black slate or Marcellus, which always retains its characters. The group occupies a thickness of some eight hundred or one thousand feet. It extends through New York, a part of Pennsylvania, Ohio, Canada West, and Michigan.

In the number and beauty of its fossils, it exceeds any of the other groups, several hundred species being already known in the State of New York alone.

The *Tully Limestone.* This may be regarded as a subordinate member of the preceding group. It is a mass of shaly limestone, twenty to fifty feet thick. It contains some fossils not known in the Hamilton group, the most peculiar of which is the *Atrypa cuboides.*

Genesee Slate. This is a black, fissile rock, splitting in thin, even laminæ, and nearly destitute of fossils. It holds a very conspicuous position, forming the junction between the calcareous shales below, and the argillaceous shales and shaly sandstones destitute of lime, above. There is also, beyond this point, an almost entire change in the fossils.

Portage Group. This is so named from the rocks exposed in the three successive falls at Portage, and in the banks of the Genesee River below. It consists of a series of shales and shaly sandstones, nearly destitute of calcareous matter, and containing few fossils.

This group has been described as consisting of three members: 1. The *Cashaqua Shale*, a soft, green shale, with nodules of a semi-calcareous rock, or shaly sandstone; 2. The *Gardeau Flagstones*, which are compact and firm shaly sandstones; 3. The *Portage Sandstones*, consisting of thin and thick-bedded argillaceous sandstones, which crumble on exposure to the air.

This group is very conspicuous in the western part of New York, and is seen along the shore of Lake Erie from below Dunkirk, westward beyond the eastern limits of Ohio.

Chemung Group. This consists of a series of shales, shaly sandstones, and sandstones, all of which are olive or greenish in color. Almost the only calcareous matter in this group is derived from the remains of shells. It is equally thick as the preceding group, and occupies a large extent of surface, a width of twenty or thirty miles in the southern counties of New York. Towards the east, it resembles the Hamilton group in its appearance, though the fossils are quite different. Beyond the limits of New York, it may be traced west into Ohio.

It contains few materials of economical value. Its fossils are numerous, and partake of the characters of those usually considered as characterizing rocks of the Carboniferous age.

Old Red Sandstone, or Catskill Mountain Group. Above the Chemung Group, we usually find some coarser beds of sandstone or a conglomerate; and still beyond, a series of micaceous shales and shaly sandstones of great thickness. These rocks are mostly brown or reddish, and, where not exposed, sometimes green. They are conspicuous as forming the high Catskill Mountains. This series has been regarded as the equivalent of the Old Red Sandstone of Europe; and the opinion was confirmed by the discovery of the remains of several fishes characteristic of that rock. The fish scale (fig. 167) on the chart is from this.

Notwithstanding the great thickness of this group in the Catskill Mountains, it thins out rapidly west; and while on the Chemung River, within the borders of Pennsylvania, the whole group is several hundred feet in thickness, on the Genesee River, at the southern limits of New York, it is but a few feet thick. This circumstance, with the horizontal position of the strata, render the rock interesting and remarkable; and it is evident that during its deposition there must have been repeated sinkings of the bed of the ocean, to allow of this great accumulation in the limited area which it occupies.

III. **Carboniferous System.** This system embraces a series of shales and sandstones; an extensive limestone formation; a second series of various colored shales, sandstones, and conglomerates; and, following these, beds of shale and sandstone, with beds of coal. This latter part of the series has given the designation to the whole. The shales, sandstones, and limestones contain remains of shells, corals, and fishes, showing their marine origin; while the coal has resulted from terrestrial vegetation, and the remains of land plants are every where imbedded in the shales and sandstones which accompany the coal. The following are the subdivisions:—

1. *Yellow Sandstones and Shales.* (Waverly Sandstones.) The lowest group of strata recognized as belonging to the Carboniferous period, are the yellow sandstones and shales which are very widely distributed in Ohio, Indiana, and Kentucky. These contain, in places, some thin beds of limestone. Fossil shells are abundant in the sandstones, and great numbers of crinoids are found in the shales.

In the Geological Reports of Ohio, these sandstones in part are described as the Waverly sandstones; and from the absence of the intervening rocks, these strata have not always been distinguished from the Chemung and Portage groups.

2. *Carboniferous Limestone.* This great limestone formation underlies the coal strata throughout most

of their extent. It is in great part a gray, or bluish gray limestone, weathering to a light ashen color. Some parts of it are crystalline, others compact and fine grained, and some of the strata are Oölitic in structure.

This limestone has a great thickness and extent in the Western States. It is very conspicuous along the Mississippi River, forming high cliffs above the mouth of the Ohio. It is also the rock in which all the large caves of the west occur; the Mammoth Cave, in Kentucky, and others of great extent in Indiana, are in this rock. It contains numerous fossil shells and corals; among the latter, one very remarkable and interesting form is represented on the chart, in figures 134 and 135.

3. *Red Shales and Shaly Sandstones.* Succeeding the limestone just described, there are, in some parts of the country, a series of red and brown shales and sandstones. These lie below the great conglomerate which is directly at the base of the Coal measures. In the eastern coal fields, these rocks are important, and form a conspicuous feature in the landscape; while at the west, their existence is scarcely recognized.

Carboniferous Conglomerate, or Millstone Grit. Throughout Pennsylvania, Ohio, and in some parts of Indiana and Kentucky, this coarse conglomerate lies at the base of the coal-bearing rocks. It corresponds apparently with the Millstone grit of the European Coal measures. It is composed of coarse sand and pebbles of crystalline quartz, often scarcely cohering. It forms a prominent horizon in the neighborhood of the outcropping Coal measures, and an excellent guide in searching for beds of coal.

Great Coal Measures, or Coal Formation Proper. This consists of a series of beds of soft shale, sandstone, conglomerate, and beds of coal, with, more rarely, beds of limestone. There is no regular succession throughout the whole, but repeated alternations of beds such as enumerated. In the coal fields of Pennsylvania, more than twenty successive beds of coal are known, separated from each other by beds of shale and sandstone.

The coal has all been formed from the decomposition of vegetable matter; and remains of numerous plants are found in the shale above the beds of coal, and in the "*under clay*," or soft shale underlying the coal bed, as well as in the coal itself. The fossil plants at the base are likewise different from those in the shale above, which, together with the condition of the material, showing quiet deposition, leads us to infer that these deposits were made in quiet water, and that the plants grew and were imbedded where we now find them. Moreover, the successive beds of coal are characterized by different species of ferns which undoubtedly grew at that period, and show from their perfect preservation that they suffered little disturbance before being imbedded in the mud.

The importance of this formation can scarcely be overrated. It furnishes all our coal, both anthracite and bituminous, and iron ore in large quantities is also associated with the coal beds. The sandstones afford good building material; and while some of the limestones furnish lime, others are fit for architectural and ornamental purposes. The coal serves us as fuel, fuses our ores, generates the steam for our manufactories and steamboats, and is in fact the controlling element in our mechanical, manufacturing, and commercial operations.

The extent of the coal fields in the United States is greater than in all the rest of the known world; and they are so situated as to give the greatest possible facilities for mining and transportation.

The series of strata from the base of the stratified rocks to the top of the Coal measures, is very perfect in the United States; but above this the series is very incomplete.*

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* The preceding rocks being more important to the American student in geology, from forming an essential part of the geological structure of the United States, have been mentioned in detail. For the remainder of the series, which are but imperfectly developed, or exist only in representative beds or parts of great groups, a general description only will be given.

IV. **New Red Sandstone System. Permian and Triassic Systems.** Above the Coal measures, and overlying them, sometimes conformably, and at other times unconformably, is found a series of red sandstones, red, green, and variegated shales, marls, and sandstones, with yellow magnesian limestones. These contain few traces of vegetation, and the organic remains are quite distinct from those in the rocks below. The system has been divided into *Permian* and *Triassic* systems.

The rocks recognized as of the New Red Sandstone period, are the sandstones and shales of the Connecticut River valley, New Jersey, Virginia, and North Carolina. These belong apparently to the Triassic System, and represent a portion of the upper marls and sandstones of the period, as more fully developed in Europe. The remains of fishes, and the tracks of birds, which have been so beautifully developed and illustrated by Professor Hitchcock, Dr. Deane, Mr. Redfield, and Mr. Marsh, are among the interesting fossil remains of this period in the United States.

It will be observed that no American localities are given upon the chart for any of the strata of the Permian system, none of its members having yet been found in this country.

In England, and upon the continent of Europe, gypsum and rock salt are found in the marls and sandstones of the higher part (Triassic) of the system; and hence the name saliferous, or salt-bearing.

Both in this country and in Europe, the rocks of this age are associated with igneous rocks, which, penetrating the coal formation, pass through and between the layers of sandstone and shale, and finally in many places overlie the whole, in vast masses of basaltic rocks. Examples of this are seen in the Connecticut valley, Mount Holyoke, the East and West hills, near New Haven, and the Palisades, along the Hudson River.

V. OÖLITIC SYSTEM. The several members of this system are of more or less importance in England and upon the continent of Europe. The only member recognized in the United States is a formation at Richmond, Virginia, which appears to be a representative of the Lias of Europe.

The system consists of limestones and shales. A soft bituminous coal is associated with it, and the shale contains remains of numerous ferns and other plants. The limestones have not the compact structure of those in the Palæozoic rocks, and they are often intermixed with clays and sands, and the layers separated by shaly or arenaceous beds.

This period is remarkable for the appearance of large marine reptiles. The contrast in the general features of the fossils of the Permian, Triassic, and Oölitic systems, with the preceding, is very apparent.

In Europe, the limestones of this period furnish beautiful marble; and the fine statuary marble, so long regarded as Primary, is a metamorphic limestone of this age.

VI. **Cretaceous System.** The characteristic feature of this system is the existence of extensive strata of chalk. The subdivisions include the Wealden and Neocomien groups, both of which are local; the former being scarcely known out of England, and the latter being only recognized on the continent of Europe. Beyond these, we notice three stages in the Cretaceous system:—the Green sand, upper and lower, with the gault or chalk marl; the Lower chalk, and the Upper chalk, with the Pisolite or Maestricht beds.

The lower and middle portions of this system are represented in the United States, east of the Mississippi River only by the Green sand of New Jersey and some of the Southern States. West of the Mississippi River, and towards the base of the Rocky Mountains, the Cretaceous system is very extensive, reaching from north of the Missouri River southwest into Texas.

The fossils of this system represented on the chart, are characteristic both in America and Europe.

VII. **Tertiary System.** This consists of three distinct groups, representing distinct periods of deposition. These are the *Eocene*, *Miocene*, and *Pliocene*.

The Eocene formation in the United States consists of beds of green sand, yellow limestone, and admixtures of clay and sand.

London clay and the coarse limestones of Paris belong to this period.

The Miocene, or Middle Tertiary, in the United States, consists of various sands and clays.

These older Tertiary formations extend from Maryland through Virginia, North and South Carolina, Georgia, Alabama, Louisiana, and Mississippi. They are characterized by immense numbers of shells, and also by the remains of sharks, and several peculiar species of cetaceans.

The Pliocene formation has not been clearly recognized in the United States. The Norfolk crag of England, the sub-Appenine beds of Southern Europe, and extensive deposits in Sicily, belong to this period.

VIII. MODERN OR QUATERNARY PERIOD. *Drift.* Succeeding the Tertiary deposits proper, is the period of the Drift. This term is applied to superficial materials, consisting of sand, gravel, clay, pebbles, and boulders, whether deposited from water, and thus assorted and stratified, or mingled together without order or stratification, bearing evidence of having been transported by other means than water.

The source from which the drift and all other superficial deposits are derived, is the older rock formations which have been broken up and more or less comminuted by the action of water and the fragments among themselves. Owing to this circumstance, a single rock formation or group of strata has, by the breaking up and transportation of its broken materials, formed the superficial deposits over wide areas, and thus given origin to the soils, and consequently the vegetation, of the surface.

LIST OF FOSSILS

FIGURED UPON THE CHART.*

I. PALÆOZOIC FOSSILS,

INCLUDING

LOWER AND UPPER SILURIAN, DEVONIAN, AND CARBONIFEROUS.

Fig. 1. **Buthotrephis gracilis.** *Clinton Group.* Oneida county, New York.

Fig. 2. **Chætetes Lycoperdon.** *Trenton Limestone and Hudson River Group.* Trenton Falls, Mohawk valley, New York; Cincinnati, Maysville, and many other localities at the West.

Fig. 3. **Streptelasma corniculum.** *Trenton Limestone.* Trenton Falls, New York; Ohio, Wisconsin, and Tennessee.

Fig. 4. **Favistella stellata.** *Hudson River Group.* Madison, Indiana; Nashville, Tennessee; Drummond's Island.

Fig. 5. **Graptolithus ramosus.** *Hudson River Group.* Albany, New York.

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* The name of the fossil is first given, and following it the name of the particular rock or group, and lastly the name of one or more localities.

Fig. 6. **Graptolithus pristis.** *Hudson River Group.* Mohawk and Hudson River valleys.

Fig. 7. **Stictopora ramosa.** *Trenton Limestone.* Middleville and Trenton Falls, New York.

Fig. 8. **Conophyllum Niagarense.** *Niagara Group.* Lockport, New York.

Fig. 9. **Caninia Helderbergiæ.** *Delthyris Shaly Limestone.* Base of Helderberg Mountain, Albany county, New York.

Fig. 10. **Catenipora escharoides.** *Niagara Limestone and Clinton Groups.* Western New York, Wisconsin, Iowa, Kentucky, &c.

Fig. 11. **Heterocrinus simplex.** *Blue Limestone,* (age of Hudson River Group.) Ohio, Indiana, and Tennessee.

Fig. 12. **Glyptocrinus dodeka-dactylus.** *Hudson River Group.* New York. "Blue Limestone," Cincinnati, Ohio.

Fig. 13. **Ichthyocrinus lævis.** *Shale of the Niagara Group.* Lockport, New York; also in limestones of Tennessee.

Fig. 14. **Dendrocrinus longidactylus.** *Niagara Group.* Lockport, New York.

Fig. 15. **Encalyptocrinus** (*Hypanthocrinus*) **decorus.** *Shale of the Niagara Group.* New York and Tennessee.

Fig. 16. **Caryocrinus ornatus.** *Niagara Group.* New York and Tennessee.

Fig. 17. **Caryocrinus ornatus.** A young specimen, with a portion of the arms attached.

Fig. 18. A part of the column and root of the same. This species occurs, in the *Niagara Group,* at Rochester and Lockport, New York; Glades of Decatur county, Tennessee.

Fig. 19. **Callocystites Jewettii.** *Niagara Shale.* Lockport, New York.

Fig. 20. **Lepadocrinus Gebhardii.** *Pentamerus ga-*

leatus Limestone, (of Lower Helderberg limestones.) Helderberg Mountains and Schoharie.

Fig. 21. Joints of the column of the same. The figure between this and fig. 20 is a single plate of the body.

Fig. 22. **Palæaster** (*Asterias*) **matutina.** This is an ancient representative of the modern star fishes. *Trenton Limestone.* New York.

Fig. 23. **Schizocrinus nodosus.** Structure of the body and arms, in part. *Trenton Limestone.* New York.

Fig. 24. Part of an arm of the same, with the plates and tentaculæ attached.

Fig. 25. **Homocrinus.** Structure of the body. *Trenton Limestone.* Mohawk valley, New York.

Fig. 26. **Lingula prima.** *Potsdam Sandstone.* New York, St. Croix, and Wisconsin Rivers.

Fig. 27. **Lingula quadrata.** *Trenton Limestone and Hudson River Group.* New York, Ohio, Wisconsin, and Iowa; also in Lower Silurian rocks in Europe.

Fig. 28. **Orthis calligramma.** Lower Silurian rocks of Europe.

Fig. 29. **Orthis testudinaria.** *Trenton Limestone and Hudson River Group.* New York and Ohio.

Fig. 30. **Orthis plicatella.** *Trenton Limestone.* New York. *Blue Limestone.* Ohio.

Fig. 31. **Orthis tricenaria.** *Trenton Limestone.* New York, Wisconsin, Iowa, Tennessee, &c.

Fig. 32. **Orthis flabellulum.** *Niagara Group.* Rochester, Lockport, &c., New York.

Fig. 33. **Leptæna alternata.** *Trenton Limestone and Hudson River Group.* Middleville, Trenton Falls, Lowville, Watertown, &c., New York; Cincinnati, Ohio; Madison, Indiana; Maysville, Kentucky; Nashville, Tennessee; near Galena, Plattville, and Mineral Point, Wisconsin; Illinois; Dubuque, Iowa; Falls of St. Anthony.

Fig. 34. **Leptæna filitexta.** *Trenton Limestone.* New

York. Lower part of *Blue Limestone*, in Tennessee, Ohio, Wisconsin.

Fig. 35. **Leptæna depressa.** *Niagara Group, Lower and Upper Helderberg Limestones.* New York.

Fig. 36. **Spirifer lynx.** *Trenton Limestone and Hudson River Group.* New York, Ohio, Kentucky, &c.

Fig. 36 *a*. Smaller variety of the same.

Fig. 37. **Spirifer Niagarensis.** *Niagara Group.* Wolcott, Rochester, Lockport, and other places in New York.

Fig. 38. **Spirifer rugosa.** *Lower Helderberg Limestones.* Base of Helderberg Mountains, Schoharie, Carlisle, and other places, New York; Pennsylvania, Virginia, and glades of Decatur county, Tennessee.

Fig. 39. **Spirifer varica.** *Delthyris Shaly Limestone.* Base of the Helderberg Mountains, New York.

Fig. 40. **Spirifer macropleura.** *Delthyris Shaly Limestone.* Base of Helderberg Mountains, New York, Pennsylvania, Virginia, and Tennessee.

Figs. 41, 42, and 43. **Atrypa increbescens.** *Trenton Limestone and Hudson River Group. Blue Limestone of the West.* Trenton Falls, Middleville, and other places, New York; Cincinnati, Ohio; Maysville, Kentucky; Madison, Indiana; Nashville, Tennessee; and other western localities. The species is remarkably variable in size and proportions, depending on age and other circumstances.

Fig. 44. **Atrypa reticulata.** *Niagara, Lower and Upper Helderberg Limestones, and Hamilton Group.* Lockport, New York, Helderberg Mountains, Genesee valley, Eighteen Mile Creek, Lake Erie, and numerous western localities.

Fig. 45. **Atrypa æquiradiata.** *Upper Member of the Lower Helderberg Limestones.* Helderberg Mountains and Schoharie.

Fig. 46. **Pentamerus galeatus.** *Pentamerus Lime-*

stone. Helderberg Mountains and Schoharie, New York; Pennsylvania, Virginia, and Tennessee.

Fig. 47. **Pentamerus oblongus.** *Clinton Group.* Near Rochester and Wolcott, New York. *Limestone of Niagara Group.* Wisconsin, Illinois, Iowa, Kentucky, and Tennessee.

Fig. 48.* Cast of **Pentamerus oblongus.** This species occurs in the condition of casts in most of the western localities.

Fig. 49. **Atrypa obesa.** *Upper Pentamerus Limestone.* Base of the Helderberg Mountains.

Fig. 50. **Ambonychia** (*Pterinia*) **radiata.** *Hudson River Group.* Oswego and Lewis counties, New York; shore of Little Bay des Noquets, Madison, Indiana; Cincinnati, Ohio.

Fig. 51. **Modiolopsis modiolaris.** *Hudson River Group.* Same localities as the preceding species.

Fig. 52. **Avicula.** *Lower Helderberg Limestones.* Helderberg Mountains, New York.

Fig. 53. **Avicula.** *Lower Helderberg Limestones.* Helderberg Mountains, Schoharie, Catskill.

Fig. 54. **Murchisonia bellacincta.** *Trenton Limestone.* Middleville, Trenton Falls, Lowville, and Watertown, New York; Ohio, Indiana, Kentucky, and Tennessee.

Fig. 55. **Murchisonia bicincta.** *Black River and Trenton Limestones.* Trenton Falls, Middleville, and Watertown, New York; Wisconsin, Tennessee.

Fig. 56. **Acroculia acuminata.** *Delthyris Shaly Limestone.* Helderberg Mountains and Schoharie, New York.

Fig. 57. **Acroculia Gebhardii.** Same position and localities as the preceding species.

Fig. 58. **Platyostoma ventricosa.** Same position and localities as the preceding.

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* On a few copies of the chart it is marked 18, but is known by being the next figure to the right of 47.

Fig. 59. **Cyrtolites ornatus.** *Hudson River Group.* Oswego and Lewis counties, New York. In the same geological position in Ohio, Indiana, and Tennessee.

Fig. 60. **Bellerophon bilobatus.** *Trenton Limestone and Hudson River Group.* New York, Ohio, Indiana, Kentucky, Wisconsin, and Iowa.

Fig. 61. **Trocholites ammonius.** *Trenton Limestone.* Middleville, New York.

Fig. 62. **Orthoceras multacameratum.** *Birds-eye Limestone.* Black River valley, New York; Tennessee.

Fig. 63. **Ormoceras tenuifilum.** *Black River Limestone.* Watertown, New York; Northern Michigan, Wisconsin, and Tennessee.

Fig. 64. **Endoceras proteiforme.** *Trenton Limestone.* Middleville and Trenton Falls, New York; Northern Michigan, and Tennessee.

Fig. 65. **Beyrichia tuberculata.** *Upper Silurian strata of England.* (This form of crustacean is usually known as *Agnostus.*)

Fig. 66. **Cytherina fabulites.** *Upper part of Birds-eye, and in Black River Limestone.* Watertown, New York; Mineral Point, Wisconsin, and in Tennessee.

Fig. 67. **Cytherina spinosa.** (The position of the valve reversed.) *Niagara Group.* Lockport, New York.

Fig. 68. **Agnostus integer.** *Silurian rocks of Bohemia.*

Fig. 69. **Trinucleus concentricus.** *Trenton Limestone and Hudson River Group.* Glen's Falls, Trenton Falls, Oswego, Lewis, and Jefferson counties, New York; Cincinnati, Ohio, and other western localities.

Fig. 70. **Calymene** (*Triarthrus*) **Beckii.** *Trenton Limestone, Utica Slate and Hudson River Group.* Mohawk valley, Turin, in Lewis county, New York; Cincinnati, Ohio.

Fig. 71. **Isotelus gigas.** *Trenton Limestone.* Trenton Falls, Middleville, Watertown, and Sacket's Harbor, New York; Cincinnati, Ohio.

Fig. 72. **Illænus crassicauda.** *Trenton Limestone, and other Lower Silurian strata.* Trenton Falls, Watertown, &c., New York.

Fig. 73. **Ceraurus pleurexanthemus.** *Trenton Limestone.* Trenton Falls, Middleville, and Watertown, New York; Cincinnati, Ohio; Tennessee.

Fig. 74. **Homalonotus delphinocephalus.** *Niagara Group.* Rochester and Lockport, New York.

Fig. 75. **Phacops limulurus.** *Niagara Group.* Rochester and Lockport, New York.

Fig. 76. **Calymene Blumenbachii,** var. *Niagarensis. Niagara Group.* Wolcott, Rochester, and Lockport, New York.

Fig. 77. **Lichas** (*Platynotus*) **Boltoni.** *Niagara Group.* Lockport, New York.

Fig. 78. **Phacops nasutus.** *Delthyris Shaly Limestone.* Base of Helderberg Mountains and Schoharie, New York.

Fig. 79. **Acidaspis elliptica.** *Silurian rocks.* Europe. A similar species (in fragments) occurs in the Lower Helderberg limestones.

Fig. 80. **Phacops Hausmanii.** *Lower Helderberg Limestones.* Base of Helderberg Mountains and Schoharie, New York; near Rumsey, Virginia, and in Tennessee.

Fig. 81. **Eurypteris remipes.** *Onondaga Salt Group.* Waterville and Williamsville, New York.

Fig. 82. **Onchus Deweyii.** *Niagara Group.* Lockport, New York. This is the earliest well-defined form of a defensive fin bone of a fish, though fragments have been seen in the Clinton Group.

Fig. 83. **Osteolepis.** A restored figure from Agassiz's "Poissons Fossiles." Professor Agassiz says that some

scales of fishes from Silurian strata seen by him are more nearly like those of *Osteolepis* than of any known genus.

FOSSILS OF THE DEVONIAN SYSTEM.

Fig. 84. **Lepidodendron.** [?] *Chemung Group.* Chemung county, New York.

Fig. 85. **Heliophyllum.** *Hamilton Group.* Genesee valley, shore of Lake Erie, at Eighteen Mile Creek.

Fig. 86. **Lithostrotion.** *Corniferous Limestone.* New York.

Fig. 87. **Cyathophyllum dianthus.** *Upper Helderberg Limestones.* Helderberg Mountains, and westward.

Fig. 88. **Favositcs gothlandica.** *Upper Helderberg Limestones.* Helderberg Mountains, New York; Ohio, Kentucky, and Tennessee.

Fig. 89. **Cyathocrinus** [?] **ornatissimus.** *Portage Group.* Shore of Lake Erie, Chatauque county, New York.

Figs. 90 and 91. Portions of *Crinoidal columns. Onondaga Limestone.* Helderberg Mountains to the Niagara River, at Black Rock; Ohio, Indiana, Kentucky, &c. Columns of this character are remarkably characteristic of the Onondaga limestone.

Fig. 92. **Nucleocrinus elegans.** *Hamilton Group.* Moscow, and other localities in the Genesee valley, New York.

Fig. 93. **Strophodonta demissa.** *Hamilton Group.* Genesee valley, shore of Lake Erie.

Fig. 94. **Chonetes carinata.** *Hamilton Group.* Seneca and Cayuga Lake valleys, Genesee valley, shore of Lake Erie, New York.

Fig. 95. **Spirifer medialis.** *Hamilton Group.* Genesee valley, New York.

Fig. 96. **Spirifer mucronata.** *Hamilton Group.* Madison county and westward to the shores of Lake Erie.

Fig. 97. **Spirifer cultrijugatus.** *Upper Helderberg Limestones.* Western New York, Ohio, and Kentucky.

Fig. 98. **Calceola sandalina.** *Devonian rocks of the Eifel, Germany.* Specimens from the *Upper Helderberg Limestones*, in Kentucky and Tennessee.

Fig. 99. **Atrypa elongata.** *Oriskany Sandstone.* Helderberg Mountains, Schoharie, &c., New York.

Fig. 100. **Atrypa aspera.** *Hamilton Group.* Genesee valley, shore of Lake Erie, New York.

Fig. 101. **Atrypa concentrica.** *Hamilton Group.* Seneca and Cayuga Lake shores, Genesee valley, shore of Lake Erie, New York.

Fig. 102. **Avicula flabella.** *Hamilton Group.* Madison county, New York.

Fig. 103. **Avicula longispina.** *Chemung Group.* Steuben county.

Fig. 104. **Cypricardia** [?] **rhomboidea.** *Hamilton Group.* Cayuga and Seneca Lake valleys, New York.

Fig. 105. **Grammysia Hamiltonensis.** *Hamilton Group.* Madison county, valleys of Cayuga and Seneca Lakes, New York.

Fig. 106. **Loxonema nexilis.** *Hamilton Group.* Madison county, valleys of Cayuga and Seneca Lakes, New York.

Fig. 107. **Pleurotomaria sulcomarginata.** *Hamilton Group.* Madison county, New York.

Fig. 108. **Acroculia dumosa.** *Corniferous Limestone.* Helderberg Mountains, New York; Ohio, Indiana, Kentucky, and Tennessee.

Fig. 109. **Goniatites.** *Marcellus Shale.* Schoharie and Manlius, New York.

Fig. 110. **Phacops selenurus.** *Corniferous Limestone.* Helderberg Mountains, Schoharie, Cazenovia, New York.

Fig. 111. **Phacops** (*Cryphæas*) **calliteles.** *Hamilton Group.* Valleys of Cayuga and Seneca Lakes, Genesee valley, shore of Lake Erie, New York.

Fig. 112. **Homalonotus Dekayii.** *Hamilton Group.* Cazenovia, and other localities in Madison county, New York.

Fig. 113. **Phacops bufo.** *Hamilton Group.* Madison county, valleys of Cayuga and Seneca Lakes, Genesee valley, shore of Lake Erie, New York; Canada West, Ohio, and other western localities.

Fig. 114. **Cephalaspis Lyellii.** *Old Red Sandstone,* Scotland.

Fig. 115. **Ptericthys cornutus.** *Old Red Sandstone,* Scotland.

Fig. 116. Scales of **Ptericthys cornutus.**

Fig. 117. **Holoptychius nobilissimus,** a single scale *Red Sandstone of the Catskill Mountain Group.* Blossburg, Pennsylvania. This species occurs, with the two preceding species, in the *Old Red Sandstone* of Scotland.

Fig. 118. **Byssacanthus crenulatus.** The bony ray or dorsal spine. (*Ichthyodorulite.*) *Old Red Sandstone.* Russia.

Fig. 119. **Dendrodus latus,** a tooth. *Old Red Sandstone.* Scotland.

Fig. 120. **Coccosteus decipiens.** Teeth of this species. *Old Red Sandstone.* Scotland.

Fig. 121. **Dendrodus sigmoidalis,** a tooth. *Old Red Sandstone.* Scotland. Teeth of a species of *Dendrodus* and of *Coccosteus* are associated with the scales of *Holoptychius,* (fig. 117,) in the *Red Sandstone* of Blossburg, Pennsylvania.

Fig. 122. **Diplocanthus striatus,** a spine. *Old Red Sandstone.* Scotland.

Fig. 123. **Dipterus.** A restored form from the fragments occurring in the *Old Red Sandstone* of Scotland.

FOSSILS OF THE CARBONIFEROUS SYSTEM.

Fig. 124. **Sphenophyllum erosum.** *Coal Shale of Carboniferous formation.*

Fig. 125. **Asterophyllites equisetiformis.** *Coal Shale.*

Fig. 126. **Pecopteris Sillimanii.** *Coal Shale.* Pennsylvania and Ohio.

Fig. 127. **Pecopteris.** *Coal Shale.* Pennsylvania and Ohio.

Fig. 128. **Neuropteris.** *Coal Shale.* Pennsylvania and Ohio.

Fig. 129. **Sphenopteris elegans.** *Coal Formation.* Europe.

Fig. 130. **Stigmaria ficoides.** *Coal Formation.* Europe and America.

Fig. 131. **Sigillaria.** A part of the stem and roots, as it stands in a coal mine near Liverpool, England.

Fig. 132. **Sigillaria.** A portion of the surface enlarged from the preceding figure, but still less than the natural size.

Fig. 133. **Calamites approximata.** *Coal Shale.* Europe and America.

Fig. 134. **Archimedes.** *Carboniferous Limestone.* Indiana, Illinois, and Kentucky.

Fig. 135. **Polypora.** *Carboniferous Limestone.* St. Louis, Missouri.

Fig. 136. A portion of the poriferous surface of the preceding fossil enlarged.

Fig. 137. **Pentremites florealis.** *Carboniferous Limestone.* Indiana, Kentucky, Tennessee, and Alabama.

Fig. 138. **Pentremites pyriformis.** *Carboniferous Limestone.* Same localities as the preceding.

Fig. 139. **Actinocrinus 30-dactylus.** *Carboniferous Limestone of England.*

Fig. 140. **Terebratula hastata.** *Carboniferous Lime-*

stone of England. A similar or identical species is known in the Carboniferous limestone of Indiana.

Fig. 141. **Spirifer attenuatus.** *Limestone, alternating with Coal beds.* Ohio, Indiana, and Kentucky.

Fig. 142. **Spirifer.** *Yellow Sandstones, below the Carboniferous Limestones.* Ohio, Indiana.

Fig. 143. **Productus punctatus.** *Carboniferous Limestone.* Kentucky, Ohio.

Fig. 144. **Productus semireticulatus.** *Carboniferous Formation.* Pennsylvania, Ohio, Indiana, Kentucky, Alabama, and Missouri.

Fig. 145. **Monotis.** *Yellow Sandstones, below the Carboniferous Limestone.* Ohio and Indiana.

Fig. 146. **Allorisma.** *Yellow Sandstones, below Carboniferous Limestone.* Ohio, Indiana, and Kentucky.

Fig. 147. **Macrocheilus.** *Coal Measures.* Ohio.

Fig. 148. **Euomphalus catillus.** *Carboniferous Formation.* Europe.

Fig. 149. **Bellerophon tenuifascia.** *Carboniferous Limestone of Europe.*

Fig. 150. **Goniatites striatus.** *Coal Shale.* Europe.

Fig. 151. **Phillipsia globiceps.** *Carboniferous Formation of Ireland.*

Fig. 152. **Dithyrocaris Scouleri.** *Carboniferous rocks of Ireland.*

Fig. 153. **Limulus trilobitoides.** *Coal Measures.* England.

Fig. 154. **Cochlearus contortus.** *Coal Formation.* Europe.

Fig. 155. Scale of **Megalichthys Hibbertii.** *Coal Measures.* Scotland.

Fig. 156. Tooth of **Psammodus longidens.** *Carboniferous.* Europe.

Fig. 157. **Megalicthys Hibbertii.** A tooth. *Coal Measures.* Scotland.

Figs. 158 and 159. Teeth of **Diplodus gibbosus.** *Coal Shale.* England.

Fig. 160. Dorsal spine of **Tristychius arcuatus.** *Coal Measures.* Scotland.

Fig. 161. Spine of **Gyracanthus tuberculatus.** *Coal Measures.* England.

Fig. 162. **Pygopterus.** (Restored figure.) *Carboniferous.* Europe.

Fig. 163. **Amblypterus.** (A restored figure.) *Coal Formation of Saarbruck.*

SECONDARY FOSSILS.

FOSSILS OF THE PERMIAN, TRIASSIC, AND OÖLITIC SYSTEMS.

Fig. 164. **Neuropteris linnææfolia.** *Lias.* Richmond, Virginia.

Fig. 165. **Zamites obtusifolius.** *Lias.* Richmond, Virginia.

Fig. 166. **Cycadites megalophyllus.** *Oölitic.* England.

Fig. 167. **Tæniopteris magnifolius.** *Lias.* Richmond, Virginia.

Fig. 168. **Anthophyllum obconicum.** *Coral Rag.* Würtemburg, Germany.

Fig. 169. **Astrea tubulosa.** *Coral Rag.* Würtemburg, Germany.

Fig. 170. **Caryophyllia annularis.** *Coral Rag.* England.

Fig. 171. **Encrinites liliiformis.** *Muschelkalk.* Near Göttingen.

Fig. 172. **Apiocrinites rotundus.** *Oölite.* Bradford, England.

Fig. 173. **Apiocrinites rotundus.** (Restored figure.) *Oölite.* Bradford, England.

Fig. 174. **Cidaris coronata.** *Coral Rag.* England.

Fig. 175. **Terebratula digona.** *Oölite.* England and Germany.

Fig. 176. **Trigonia costata.** *Oölite.* England and the continent of Europe.

Fig. 177. **Gryphæa incurva.** *Lias.* England and the continent of Europe.

Fig. 178. **Ammonites nodosus.** *Muschelkalk.* Germany.

Fig. 179. **Ammonites falcifer.** *Oölite.* England.

Fig. 180. **Ammonites jason.** *Oxford Clay.* England.

Fig. 181. **Aspidorhynchus.** (Restored figure.) *Oölite.* Solenhofen, Bavaria.

Fig. 182. **Placodus Andriani.** *Muschelkalk.* Bamberg, Bavaria.

Fig. 183. **Ichthyosaurus communis.** *Lias.* England.

Fig. 184. **Plesiosaurus dolichodeirus.** *Lias.* England.

Fig. 185. **Pterodactylus crassirostris.** *Oölite.* Solenhofen, Bavaria.

Fig. 186. **Megalosaurus Bucklandii.** *Oölite.* Stonesfield, England.

Fig. 187. **Mastodonsaurus**[*] **Jaegeri.** *Keuper.* Würtemburg.

Fig. 188. **Ornithicnites.** (Tracks of birds.) *Sandstone, age of Trias.* Connecticut River valley.

Fig. 189. **Phascolotherium Bucklandii.** *Oölite.* Stonesfield, England.

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[*] *Labyrinthodon* of Owen.

FOSSILS OF THE CRETACEOUS SYSTEM.

Fig. 190. **Equisetum Lyellii.** *Wealden.* England.

Fig. 191. **Lonchopteris Mantellii.** *Wealden.* England.

Fig. 192. **Anthophyllum Atlanticum.** *Green Sand.* New Jersey.

Fig. 193. **Ventriculites.** *Chalk.* Lewes, England.

Fig. 194. **Cœloptychium agaricoides.** *Green Sand.* Westphalia.

Fig. 195. **Hallirhoe costata.** *Chalk.* England.

Fig. 196. **Idmenea contortilis.** *Yellow Limestone, Cretaceous formation.* Timber Creek, New Jersey.

Fig. 197. **Marsupites ornatus.** *Chalk.* Lewes and Brighton, England.

Fig. 198. **Ananchytes ovatus.** *White Chalk.* England.

Fig. 199. **Spatangus parastatus.** *Cretaceous formation.* New Jersey.

Fig. 199 *a*. **Galerites cretosus.** (Base of specimen.) *Chalk.* Lewes, England.

Fig. 200.* **Cidarites armiger.** *Cretaceous formation.* New Jersey.

Fig. 201. **Terebratula Sayii.** *Green Sand.* New Jersey.

Fig. 202. **Terebratula Harlani.** *Cretaceous Limestone.* New Jersey.

Fig. 203. **Gryphæa convexa.** *Green Sand.* New Jersey.

Fig. 204. **Pecten quinquecostatus.** *Green Sand.* New Jersey.

Fig. 205. **Plagiostoma spinosum.** *Upper White Chalk.* England.

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* In some copies of the chart marked 203.

Fig. 206. **Inoceramus.** *Cretaceous formation.* Near the base of the Rocky Mountains.

Fig. 207. **Ammonites Conradi.** *Cretaceous formation.* Alabama.

Fig. 208. **Scaphites Iranii.** *Neocomien.* Europe.

Fig. 209. **Turrilites catenatus.** *Chalk.* France.

Fig. 210. **Hamites attenuatus.** *Gault.* England and continent of Europe.

Fig. 211. **Baculites anceps.** *White Chalk.* England.

Fig. 212. **Belemnitella Americana.** *Green Sand.* New Jersey.

Fig. 212*.† Claw of **Astacus Sussexiensis.** *Chalk.* Lewes, England.

Fig. 213. **Macropoma Mantellii.** *Cretaceous formation.* Lewes, England.

Fig. 214. Coprolite of **Macropoma Mantellii.**

Fig. 215. **Ptychodus spectabilis.** A dorsal spine. *Chalk.* Lewes,-England.

Fig. 216. **Palæorhyncum latum.** *Slates of Glaris,* Switzerland.

Fig. 217. **Beryx microcephalus.** *Scales. Middle Chalk.* Lewes, England.

Fig. 218. **Corax pristodontes.** *Chalk.* Europe.

Fig. 219. **Ptycodus Mortoni.** *Cretaceous formation.* Alabama.

Fig. 220. **Otodus appendiculatus.** *Chalk.* Europe and America.

Fig. 221. Tooth of **Iguanodon Mantellii,** (young.) *Lower Green Sand.* England.

Fig. 222. Teeth of **Iguanodon Mantellii.** An older individual, and the tooth worn.

Fig. 223. Jaw and teeth of **Mosasaurus Hoffmanii.** *Upper Chalk formation.* Maestricht.

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† 212* In some copies of the chart, the asterisk is wanting after the figures 212.

FOSSILS OF THE TERTIARY AND QUATERNARY SYSTEMS.

Fig. 224. **Mimosites Browniana.** *Tertiary.* Suffolk, England.

Fig. 225. **Pecopteris** [?] **undulata.** *Tertiary.* Rocky Mountains.

Fig. 226. **Glossopteris** [?] **[Fucoides.]** *Tertiary.* Rocky Mountains.

Fig. 227. **Sphenopteris Fremontii.** *Tertiary.* Rocky Mountains.

Fig. 228. **Madrepora palmata.** *Tertiary.* Chesapeake Bay.

Fig. 229. **Caryophyllia cespitosa.**

Fig. 230. **Anthophyllum lineatum.** *Tertiary.* Virginia.

Fig. 231. **Oculina.** *Tertiary.* Claiborne, Alabama.

Fig. 232. **Scutella Lyellii.** *Tertiary.* Alabama.

Fig. 233. **Scutella Rogersi.** *Tertiary.* Alabama.

Fig. 234. **Nummulites lævigatus.**

Fig. 235. **Nummulites lævigatus.** A section of the same. *Tertiary.* England.

Fig. 236. **Calcarina rarispina.** *Eocene Tertiary.* Paris Basin.

Fig. 237. **Spirolina stenostoma.** *Eocene Tertiary.* Paris Basin.

Fig. 238. **Terebratula lacryma.** *Tertiary.* Carolina and Alabama.

Fig. 239. **Plagiostoma dumosum.** *Eocene Tertiary.* Carolina and Alabama.

Fig. 240. **Ostrea panda.** *Eocene Tertiary.* Alabama.

Fig. 241. **Pecten Jeffersonius.** *Tertiary.* Virginia.

Fig. 242. **Pecten eboreus.** *Tertiary.* North Carolina and Virginia.

Fig. 243. **Cardita planicosta.** *Tertiary.* Alabama.

Fig. 244. **Arca idonea.** *Tertiary.* Alabama.

Fig. 245. **Pectunculus subovatus.**

Fig. 246. **Crassatella alta.** *Tertiary.* Alabama.

Fig. 247. **Astarte undulata.** *Middle Tertiary.* Virginia.

Fig. 248. **Fusus contrarius.** *Red Crag.* Norfolk, England.

Fig. 249. **Fusus quadricostatus.** *Middle Tertiary.* Maryland.

Fig. 250. **Cerithium giganteum.** *London Clay.* England.

Fig. 251. **Turritella Mortoni.** *Eocene Tertiary.* Fort Washington, Maryland.

Fig. 252. **Conus gyratus.** *Eocene Tertiary.* South Carolina.

Fig. 253. **Nautilus ziczac.** *London Clay.* England.

Fig. 254. **Cancer Leachii.** (Sheppey Crab.) *London Clay.* England.

Fig. 255. **Sciænurus.** *London Clay.* Sheppey, England.

Fig. 256. **Lophius brachysomus.** *Tertiary.* Europe.

Fig. 257. **Smerdis minutus.** *Tertiary.* Europe.

Fig. 258. **Platax macropterygius.** *Tertiary.* Europe.

Fig. 259. Spine of **Spinax.** *Tertiary.* Europe.

Fig. 260. **Notidanus primigenius.** *Molasse.* Switzerland.

Fig. 261. **Charcharodon angustidens.** *Tertiary.* South Carolina.

Fig. 262. **Charcharodon megalodon.** *Tertiary.* S. Carolina.

Fig. 263. **Andrias Scheuchzeri.** *Tertiary.* Europe.

Fig. 264. **Chelydra Murchisoni.** *Tertiary.* Europe.

Fig. 265.* Tooth of **Basilosaurus** (*Zeuglodon*) **cetoides.** *Eocene Tertiary.* Alabama.

Fig. 266. **Palæotherium magnum.** *Montmartre.* France.

Fig. 267. **Palæotherium gracile.** *Montmartre.* France.

Fig. 268. Molar tooth of **Elephas primigenius.** *Lacustrine deposits of Quaternary.* Europe and America.

Fig. 269. Lower jaw of **Dinotherium giganteum.** *Tertiary.* Europe.

Fig. 270. **Megatherium Cuvieri.** *Quaternary.* Pampas of South America; Georgia.

Fig. 271. Teeth of **Megatherium Cuvieri.**

Fig. 272. Skull of **Ursus spelæus,** (Cavern Bear.) *Modern or Quaternary Period.* England and continent of Europe.

Fig. 273. Skull of **Castoroides Ohiöensis.** *Lacustrine deposits of Quaternary Period.* New York and Ohio.

Fig. 274. **Megaceras Hibernicum.** *Peat Mosses of Ireland.*

Fig. 275. **Mastodon maximus.** *Lacustrine deposits of Quaternary.* All parts of the United States.

Fig. 276. **Fossil Fly.** (Family *Tipulidæ.*) *Fresh Water formation.* Aix, Provence.

Fig. 277. **Dinornis.** *Quaternary Period.* New Zealand.

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* This figure, on the left of 268, is, by mistake, numbered 271 on some copies of the chart.

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